Section 4.0
Sustainability by Hazard Type

This section suggests specific approaches to incorporating sustainable practices into recovery and mitigation planning for the following types of hazards:

- Flooding
- Earthquakes
- Coastal storms
- Tornadoes
- Wildfires
- Landslides.

The hazard-specific discussions are followed by a relevant case study that provides one or more examples of sustainable mitigation processes. The Sustainability Planner new to emergency management should obtain background information on the particular hazards relevant to the disaster deployment. The FEMA document, *Multi-Hazard Identification and Risk Assessment: The Cornerstone of the National Mitigation Strategy*, provides an excellent overview on a broad range of natural hazards (see annotated reference in Appendix D). Understanding the anticipated intensity of a future disaster and the probable reoccurrence of the next threshold event that could trigger a disaster declaration is critical in identifying appropriate mitigation and sustainability approaches.

The discussions below outline different approaches to incorporating sustainable practices into the disaster recovery and mitigation planning processes. The recommended approaches are not intended to be all-inclusive. The relevance of each approach varies depending on disaster damages, the history of past natural disasters in the area, the statistical probability of future disasters, and community interest and political realities.

4.1 All Hazards

Hazard mitigation specialists working out of a DFO are understandably focused on evaluating mitigation opportunities relevant to the natural hazard event that led to the disaster declaration. However, it is important that the mitigation staff and

Sustainability Planner step back at this point and evaluate mitigation and sustainable redevelopment opportunities from a multi-hazard perspective. Are there other hazards present that would leave reconstruction vulnerable to disaster? Some excellent examples of a multi-hazard approach come from recent hurricane disaster declarations in the U.S. Virgin Islands and in Puerto Rico. Mitigation activities following these declarations focused on repair and reconstruction of structures damaged or destroyed by high winds. Where feasible from a cost and engineering perspective, mitigation specialists also considered incorporating seismic strengthening of the structures in reconstruction because of the high seismic risk present in this part of the Caribbean.

Many aspects of mitigation and sustainable redevelopment are common to all hazards. Therefore, if major reconstruction is part of the overall recovery effort, the following factors should be considered in addressing all hazard types:

Extent of Damage

Obviously, the more extensive the damage to a community, the greater the opportunity for incorporating sustainable redevelopment into the recovery effort. Following a major disaster, many communities may find it advantageous to reexamine how land uses can be rearranged and how the basic configuration of streets and utilities might even be altered to improve access and services. The first question for the Sustainability Planner is, How can the community avoid repetitive losses through the reconstruction process? If damage is extensive and the continued risk high in a particular area, alternative land uses such as open space or recreation may be appropriate. However, changing land use to avoid repetitive damages may not be a sound planning option nor politically feasible.

Where the extent of damage is limited and replacement of previous uses is desirable, significant measures may be employed on a structure-by-structure basis to provide for increased disaster resistance, energy efficiency, and environmental sensitivity.

Type and Age of Affected Facilities and Structures

As a general rule, recently developed areas are more likely to consist of homes and businesses where the owners have adequate insurance or other financial means to restore their properties. In addition, recent developments should more closely reflect community needs and current planning standards. Unless these developments are located in an area that is highly vulnerable to natural disasters, it is probable that the development will be returned to predisaster conditions. In these situations, there are opportunities to promote sustainability by recommending the use of building materials and replacement equipment that are energy efficient and disaster resistant.

In older disaster-damaged areas, other questions may be asked before the community embarks on reconstruction. Older residential or community areas were designed and built to meet community needs at that time. Does the community want things put back the way they were, or would another land use pattern better meet current needs? Housing needs today have shifted dramatically from the prevalent three-bedroom, single-family detached subdivisions built during the 1950s and 1960s. Based on an assessment of the community s needs, it may be appropriate to provide a greater diversity of housing types in a typical reconstruction project. In these situations, it may be appropriate for the community to consider initiating a long-term recovery planning effort to evaluate alternative reconstruction strategies.

Environmental and Social Considerations

The Sustainability Planner should help to ensure that community recovery plans and proposed mitigation measures are environmentally sensitive, respect cultural and historic resources, and contribute to the sustainability of the residential and commercial elements of the community. When Federal funds are used in the reconstruction effort, Federal environmental and historic preservation requirements such as NEPA, NHPA, CoBRA, and the Endangered Species Act (ESA) may become an issue in the overall recovery effort. The Sustainability Planner can help local communities by facilitating an expedited review process and helping to resolve review and permitting issues as they arise.

Regulatory Controls

Because there is typically pressure to rebuild as soon as possible, it is important to assess current regulatory controls to determine whether they promote commonly accepted sustainable building techniques and rational land use patterns. A Sustainability Planner might provide recommendations to modify or amend zoning regulations to allow a greater diversity of housing types or promote flexibility in the review process to expedite approvals for reconstruction activities. If regulatory controls are lacking and there is hesitancy on the part of property owners to voluntarily incorporate sustainable development measures, the community may consider a building permit moratorium. In this case, no building permits are issued for a specified time (30 to 60 days) to allow time to identify and implement changes to relevant ordinances. Moratoriums are often controversial and may not be politically feasible; however, they can be crafted to apply only to substantially damaged structures. Another word of caution: moratoriums must be clearly justified and have the support of key local officials.

Public Education and Outreach

Community outreach is an effective sustainable redevelopment measure in almost all disaster declarations. Regardless of whether homes and businesses are only partially damaged or a substantial reconstruction effort is necessary, public outreach is crucial to provide timely information to the community. The Sustainability Planner needs to enroll people to help get the message out. Many people within the DFO organization and working at DRCs throughout the declaration area play important roles in bringing information to disaster victims. Prepare appropriate materials, hold briefings or training at the DFO or DRC, and enroll interested volunteers. Local officials especially the building permit administrator, zoning inspectors, and planners should be strong advocates in any outreach program.

4.2 Floods

Most disaster declarations are flood related. Hundreds of floods occur each year, making it one of the most common hazards in all 50 states and the U.S. territories.

Floods kill an average of 150 people a year in the United States. Property and flood damage losses amount to approximately $4 billion annually. Flood losses today are often the result of inappropriate development within the floodplain, filled wetlands, and extensive impervious surfaces. Together, these factors affect the functions and capacity of the watershed and drastically increase the risk of flooding.

Mitigation and Sustainability Approaches

Planning

- Where appropriate, consider recommending development of a stormwater management plan. Extensive shallow flooding may indicate that stormwater facilities and storm drains or drainage ditches are inadequate.
- Be cautious in recommending that a community develop a comprehensive watershed management plan, which requires considerable time and effort, during the initial stages of recovery. This is a long-term initiative that has particular relevance when the watershed draining to the affected community is not too large and falls within a limited number of political jurisdictions.
- Coordinate with NFIP experts at the DFO or at the regional level to determine if the available flood hazard data is adequate to guide redevelopment. It may be necessary to develop additional flood hazard data quickly. Because flood hazards may change over time, it is critical to ensure that hazard data is current.

Extent of Damage/Type and Age of Affected Facilities and Structures

- Elevate older, nonconforming structures above the base flood elevation (BFE).
- For older residential areas, repetitive damages are an excellent clue that hazard mitigation and sustainable redevelopment measures should be considered in the reconstruction effort.
- Encourage use of the ICC coverage provision under the NFIP. ICC coverage provides additional funding for the cost to comply with state or community floodplain management ordinance for structures have been declared substantially or repetitively damaged.

Regulatory Controls

- Use zoning regulations to keep future development away from flood hazard areas, encourage cluster development, and require underground utilities (where feasible).
- Amend subdivision regulations to minimize residential encroachments into the floodplain.
- Strengthen floodplain regulations and enforcement. The CRS provides recommendations for measures beyond the model NFIP flood ordinance s minimum requirements that local jurisdictions can adopt. An effective additional measure would be to require at least 1 foot of freeboard above the BFE.
- Consider adopting a stormwater management ordinance for future development to minimize the potential for repetitive flood damages. Many states do not mandate minimum stormwater management requirements for local jurisdictions.

Land Management and Construction Practices

- Consider a full range of structural and nonstructural measures, such as elevation, wet or dry floodproofing techniques, and acquisition. Provide technical or financial assistance to property owners to implement hazard mitigation measures.
- Move all valuables and appliances out of the basement. Place main breakers/fuse boxes and utility meters above the anticipated flood level, and secure hot water heaters to walls instead of floors, with steel straps; in new construction, locate these components on upper levels. Consider elevation for residential properties located in minimal flood zone areas.
- Consider elevation as a means of protection against future damage. The building permit administrator must consider the necessary level of flood protection required based on the potential velocity, level, frequency, and duration of future floodwaters.
- A home must be elevated or relocated out of the floodplain if it has received substantial damage (50 percent of preflood market value).
- Institute a maintenance program for stormwater detention basins, culverts, and storm drains to minimize future flooding events.
- Use structural mitigation measures such as levees, floodwalls, and shoreline protection techniques as appropriate to minimize future flood damages.
- Purchase or relocate flood-prone properties and utilize the most vulnerable part of the floodplain as a greenway, park, wildlife habitat, or other use not so vulnerable to flood damages.

Public Education and Outreach

- Create a public awareness campaign on the many benefits of floodplain preservation and restoration.
- Develop an outreach program to increase property owner participation in NFIP.

Flood Case Study: Hazard Mitigation Planning in Massachusetts

Watershed Initiatives in the Upper Mystic Basin

A Unified Initiative

Nine municipalities in the Upper Mystic Watershed Basin (UMWB), northwest of Boston, Massachusetts, are working together to address hazard mitigation planning. Following significant flood events in 1996 and 1998, both resulting in Federal disaster declarations, the UMWB communities formed an alliance based on their watershed boundaries and informed by their recognition that flood mitigation planning cannot succeed if implemented only at the local level.

By joining the alliance, these communities are participating in a unique statewide watershed initiative. This program was designed to collect and share resources and information, target present and potential impacts to natural resources, assess impacts to natural resources, and develop and implement activities to protect and improve the Commonwealth s natural resources. The communities have organized flood hazard mitigation planning on the basis of this principle. UMWB has implemented three hazard mitigation grant projects, a drainage improvement project in Arlington, the Wrights Pond Dam upgrade in Medford, and a culvert/ drainage project in Winchester. Earlier this year FEMA designated UMWB as a *Project Impact* community. This recognition provides funding and resources to continue flood mitigation planning.

Watershed Initiative/Environmental Joint Powers Agreement

The fact that flood mitigation planning must transcend political boundaries has long been recognized. However, the Massachusetts watershed initiative and the legal and institutional mechanisms that support it are far from commonplace. Following an October 1996 flood event triggered by 2 days of precipitation combining to exceed the 100-year event, the Massachusetts Emergency Management Agency (MEMA) and the Department of Environmental Management hosted a workshop to facilitate development of a coordinated watershed approach to flood hazard mitigation. Since that workshop, the original communities Arlington, Medford, Winchester, and Woburn expanded their defined boundaries to include the communities of Burlington, Lexington, Reading, Stoneham, and Wilmington.

The mechanism that allowed the UMWB communities to receive Federal funding as a distinct, geographically delineated unit defined by watershed boundaries (drainage area) was twofold:

- The statewide watershed initiative, a program of the Massachusetts Executive Office of Environmental Affairs.
- The statewide legislation that set up an Environmental Joint Powers Agreement (EJPA).

The Watershed Initiative has continued to evolve since its inception in 1993. It originally was designed to address water quality within the state and particularly to reorganize the procedures for issuance of wastewater permits; however, use of the initiative to address water quantity issues through flood mitigation planning represents a unique application. The creation of the Upper Mystic River Watershed Agency through the adoption of an EJPA is the first application of enabling legislation adopted by a state legislature.

The legislation is intended to facilitate intergovernmental action on natural resource and environmental issues, though the originally defined objective is more narrow. The EJPA allows the communities to work jointly and cooperatively to reduce or eliminate the devastating effects of flooding and other hazards in the Upper Mystic River Watershed. It authorized the creation of the Upper Mystic River Watershed Agency, which consists of one voting representative and one nonvoting alternate from each participating community. The agency is entitled to receive and expend public and private funds to defray the operational, administrative, and contractual costs of this agreement, including, but not limited to salaries, wages, transportation, and administrative overhead.

Summary

Massachusetts has demonstrated a remarkable commitment to the initiative from the outset. Twenty full-time state employees were reassigned to the UMWB team. Community councils bring together a diverse array of stakeholders to assess watershed needs and establish consensus on proposed solutions. Furthermore, the state has developed watershed teams whose members represent seven state agencies and four Federal agencies (EPA, NRCS, USFWS, USACE).

Statewide environmental regulations, including the Rivers Protection Act, serve as the foundation for the watershed initiative. The EJPA enabling legislation empowers regional coalitions to pursue public and private funding to support those environmental objectives that are valuable within the boundaries established by their encompassing watershed. Massachusetts has taken great strides in only a few years to radically alter the governmental approach to addressing environmental challenges.

4.3 Earthquakes

Earthquakes are abrupt movement of the Earth s crust caused by the sudden release of accumulated tension between or within tectonic plates, which then causes violent ground motion or trembling. Tectonic plates are rigid, 50- to 60-mile-thick sections of the Earth s crust that can move either slowly and continuously or suddenly, with resultant collisions or separations. Most earthquakes occur in areas where large plates collide or slide against one another, but others occur along fault lines on the interior of a plate. The variables that characterize earthquakes are ground motion, surface faulting, ground failure, and seismic activity. Magnitude refers to the seismic energy released during an earthquake, which is measured on the Richter Scale. Intensity is a subjective measure of the strength of the ground shaking; it is based on observed damage and varies according to proximity to the epicenter of an earthquake (the point on the earth s surface directly above the location of the rupture). Intensity is measured by the Modified Mercalli Intensity (MMI) Scale, which consists of 12 levels of intensity.

Liquefaction is an earthquake phenomenon that occurs when ground shaking causes hydric or sandy soils to lose stability and behave as viscous fluids. This characteristic is one of the most damaging; it is prevalent in areas that were developed on filled wetlands or in hydric soils that have been drained to accommodate growth. The Sustainability Planner should consider alternative land use strategies in areas where liquefaction occurs and in other areas of severe seismic risk such as active fault lines.

Damage from earthquakes includes settlement, impairment, or collapse of buildings, bridges, and dams. Underground infrastructure such as tunnels, storm drains, water wells, water lines, sewer lines, gas lines, phone lines, and electric lines, is often damaged or destroyed. Transit systems, power, water, gas, telecommunications, and other basic services are disrupted. Deaths and injuries usually occur due to falling objects or the collapse of structures.

Secondary earthquake hazards are common and result from a variety of sources. These hazards include landslides; fires from ruptured gas lines; flash or localized flooding from damaged water mains, broken dams, and seiches; tsunamis or tidal waves (from earthquakes originating at sea); and hazardous materials incidents that may release poisonous chemicals, radioactive materials, or biological waste.

Mitigation and Sustainability Approaches

Extent of Damage

The first step for the community is to determine if damaged areas can be safely restored using earthquake-resistant building techniques and land development policies; if the area should assume a different development and land use pattern to address economic or social needs; or, perhaps, if the area should be redeveloped at all.

By taking a broad view of geologic and topographic circumstances, communities can mitigate the factors that exacerbate the effects of earthquakes, such as liquefaction and attendant secondary hazards such as landslides and flooding. For example, communities might designate severe hazard risk areas such as those with steep slopes, those that are highly susceptible to liquefaction, and those adjacent to active faults and restrict future development. Sustainable development is further enhanced by proposing alternative land uses, such as open space designations, wetlands reclamation, or recreation. Outside of these areas of severe seismic risk, the adoption and enforcement of up-to-date building codes is critical to achieving a more sustainable future.

Type and Age of Affected Facilities and Structures

Following an earthquake disaster, communities should examine remaining older buildings, especially those that do not satisfy current code requirements or have not been upgraded for earthquake resistance. Communities should be cognizant of the historical value of structures and neighborhoods, and the possible hazard effects on special populations such as the elderly or handicapped, they must recover with an eye to the future the choices made today may greatly influence the extent of damages from a future seismic event.

Land Management and Construction

- Designate areas of high seismic hazard for open spaces, such as parks or greenways. This is especially relevant for developed areas that have sandy soils or have been built on infill and are more vulnerable to the effects of liquefaction or areas vulnerable to landslides.
- Prohibit construction of critical facilities in areas of high seismic risk.
- Create guidelines for evaluating proposed projects in seismic hazard areas to minimize damage from earthquakes and landslides.
- Implement programs such as density bonuses, transfer of development rights, and tax credits to encourage land developers to practice earthquake mitigation and sustainability.
- Develop programs and financial incentives for seismic upgrade of buildings.
- Consider local development standards for installation and construction of utility services and roads.

Regulatory Controls

- Update building codes to include the most current National Earthquake Hazard Reduction Program (NEHRP) recommended provisions.
- The Sustainability Planner and local building officials should become familiar with and encourage the use of FEMA s Yellow Book series of publications dealing with the seismic safety of both new construction and existing buildings.
- Some key manuals in this series include:
  - ***Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook (FEMA 154)*** and ***Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation (FEMA 155)***

    The Handbook presents a method for quickly identifying buildings posing risk of death, injury, or severe curtailment in use following an earthquake. Building inspectors are the most likely group to implement a Rapid Screening Procedure (RSP), although this report is also intended for building officials, engineers, architects, building owners, emergency managers, and interested citizens. The Supporting Documentation reviews the literature and existing procedures for rapid visual screening.
  - ***Establishing Programs and Priorities for the Seismic Rehabilitation of Buildings: Handbook (FEMA 174)*** and ***Establishing Programs and Priorities for the Seismic Rehabilitation of Buildings: Supporting Report (FEMA 173)***.

    These two volumes provide the information needed to develop a seismic rehabilitation program, with particular reference to establishing priorities. The Handbook is intended to assist local jurisdictions in making informed decisions on rehabilitating seismically hazardous existing buildings by providing nationally applicable guidelines. It discusses the pertinent issues that merit consideration, both technical and societal, and suggests a procedure whereby these issues can be resolved. The Supporting Report includes additional information and supporting

Earthquake Case Study: California Seismic Hazard Mapping

Seismic hazards can cause huge economic and physical impacts and force communities into a cycle of repetitive rebuilding. When compared to other hazards, seismic events are generally more difficult to predict, and their potential impacts more difficult to quantify. However, technology is available to help communities make the right decisions in building and adapting land uses to make their environment more sustainable.

As a result of the October 1989 Loma Prieta earthquake, the California legislature passed the Seismic Hazards Act of 1990 to identify and map the state s most prominent earthquake hazards. The State Department of Conservation established the seismic hazard zone mapping program to chart areas prone to liquefaction (failure of water-saturated soil) and earthquake-induced landslides throughout California s principal urban and major growth areas. The mapping program was originally funded by the Earthquake Insurance Fund and a portion of construction building permit fees. However, it is now supported by FEMA hazard mitigation funds.

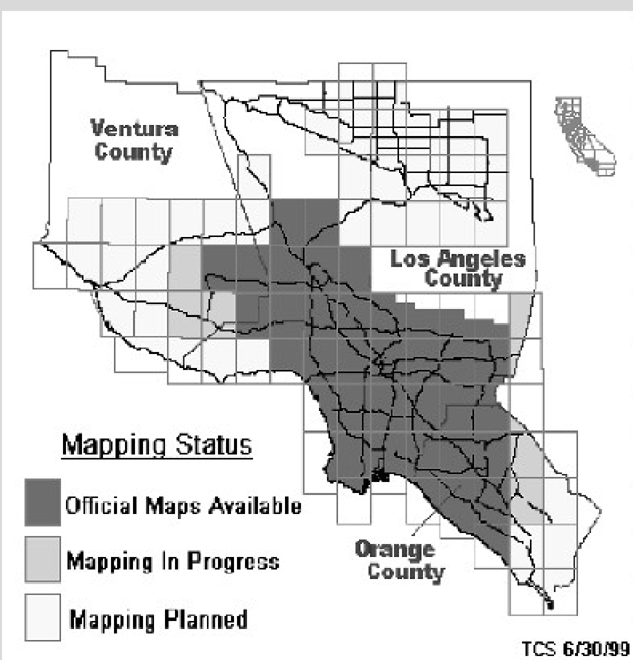
To produce the maps, Department of Conservation scientists and GIS specialists examine the latest information on surface and subsurface geology, historic groundwater levels and damage, and geologic effects of recent earthquakes. State-of-the-art GIS technology is used to integrate the information into a three-dimensional view of the ground. Each map covers an area of approximately 60 square miles.

California s seismic hazard maps offer:

- A standardized method of hazard assessment to evaluate hazard potential.
- Integration of the latest geotechnical data with state-of-the-art computer technology.
- A large scale (1:24,000) to provide a detailed look at a broad area.

The first maps produced by the program were issued in fall 1996. As of spring 2000, 43 maps of 107 cities and unincorporated areas in Los Angeles, Orange, San Francisco, and Ventura counties have been published.

A seismic hazard zone map does not show areas that should be excluded from development. Instead, it shows areas where the potential for damage is great enough so as to make it prudent to conduct geologic investigations to identify and mitigate the hazard prior to development. Mapping seismic hazards promotes the incorporation of hazard mitigation elements into structural design.



Potential seismic hazards are unique to each site, and the multiplicity of structural configurations makes it impossible to predict mitigation costs. However, in some cases, it may be possible to adequately mitigate liquefaction hazard for example-by strengthening the foundation to withstand displacements of 1.5 feet, at a typical cost of $3,000 to $4,000. Engineers indicate that in many locations this simple measure could reduce the repair expenses of liquefaction damage from an average of $70,000 to about $15,000 a substantial savings.

In the past, land use planners have often assumed that only lower density developments are suitable in geologic hazard areas. However, planners may find that the high cost of mitigating liquefaction hazards along streams, bays, canals, and coastal zones requires a higher density of development. In situations such as this, for example, the seismic hazard zone maps provide another sustainability tool to guide decision making with regard to retrofitting existing buildings, building new structures, or rebuilding after a disaster.

documentation, annotated bibliographies, and reproductions of selected laws and ordinances that are presented in summary form in the Handbook.

Public Education and Outreach

The Sustainability Planner should encourage homeowners and businesses to use nonstructural earthquake mitigation techniques, such as anchoring bookcases to walls, applying safety film to windows, and securing masonry chimneys to roof framing.

Some examples of education and outreach messages in seismic hazard areas: take such basic safety steps as bolting or strapping cupboards and bookcases to the wall, and keep heavy objects on lower shelves. To prevent gas line fires, secure water heaters with straps to a nearby wall using bands of perforated steel (commonly known as plumber s tape . Install anchor bolts every 6 feet around the perimeter of a home to prevent costly damage.

4.4 Coastal Storms

The **coastal zone** is a highly dynamic and ecologically rich environment that continuously changes under the influence of natural forces. Historically, people migrated toward the coasts because of trade, transportation, and economic opportunities. Today, as people continue to move to coastal areas for aesthetic and recreational reasons, the density of development increases along with the risk to lives and property from tsunamis, hurricanes, tropical storms, nor easters, and storm surge flooding.

A **tsunami** (harbor wave) is triggered by underwater earthquakes or landslides that push a fast-moving series of waves across the open ocean at speeds that can reach 450 miles per hour (mph). The waves are barely noticeable as they travel across deep water, but can build up to significant heights as they near land. Tsunami heights over 100 feet have been recorded. They are most common along the Pacific Coast due to seismic activity around the Pacific rim, but they can occur in the Atlantic as well. A **nor easter** is a coastal low-pressure system occurring along the Atlantic seaboard during winter months that can produce heavy amounts of precipitation, inland snow and ice, high surf, and coastal erosion. Another storm of great concern to coastal communities is the **hurricane** because of its severity, frequency, and the tremendous area that can sustain damage. A hurricane is a cyclonic **tropical storm** with winds that reach or exceed a constant speed of 74 mph. These storms bring torrential rains, high winds, and storm surges to the Gulf of Mexico, the Atlantic and Pacific coasts, and the western Pacific islands. Hurricane season extends from June 1 through November 30; on average, five hurricanes strike the United States every 3 years.

Mitigation and Sustainability Approaches

Planning

In developing mitigation and sustainability development plans, local governments gather and analyze information about the suitability of land for development. A plan that effectively incorporates sustainable development concepts guides future development by balancing environmental protection, societal needs, and economic growth. The key tenet for sustainability planning in coastal communities is to avoid intensive development in areas of high vulnerability to natural hazards.

Land Management and Construction

- **Infrastructure** Government policies may seek to locate infrastructure such as roads and sewer lines so that development is steered away from hazardous areas. The CoBRA is a Federal program that employs this unique, free market approach to resource protection and hazard avoidance (see sidebar).
- **Engineering** Seawalls, groins, jetties, and other engineering solutions are used to control the effects of erosion and wave action. However, these types of construction have the potential to increase erosion downshore of the structures, so their impacts must be carefully evaluated before they are recommended.
- **Hurricane straps** Metal fasteners or hurricane clips attach the roof to the walls of a building to reinforce its ability to sustain severe winds. When adequately sized and property installed, the straps enhance the structural integrity of a building by providing a continuous load transfer path from roof to foundation. Building codes may determine the use of hurricane straps and require that they meet both material and installation standards.
- **Shutters** Storm shutters are one of the most basic methods for high wind protection. They are placed over windows and other glass areas on the exterior of a building to protect against flying debris. They are made of plywood, corrugated metal, or polycarbonates. Building codes may determine the use of shutters and require that they meet both material and installation standards.
- **Elevation** Elevated buildings allow floodwaters to flow underneath and also make the buildings less susceptible to storm surge during a hurricane. Elevating utilities, such as hot water heaters, normally located on the ground floor or basement of a home to above expected flood or storm surge levels can prevent costly replacement after a flood. Roads, bridges, utility infrastructure, and transit facilities can also be elevated above expected flood heights.
- **Relocation** Structures that have suffered repetitive losses are favored candidates for FEMA relocation programs to move residents and buildings out of the hazard zone. The remaining property is typically acquired and maintained as open space.
- **Other measures** Other damage prevention measures available to property owners in coastal areas include wind-resistant windows, wind- and hail-resistant shingles, and hurricane-resistant doors.

Coastal Zone Management Act

CZMA, passed in 1972, is also designed to protect coastal resources, but it applies to the entire coastal zone, defined as coastal waters (including land under the water) and adjacent shorelands (including water under or on the land). The coastal zone includes islands, transitional and intertidal areas, salt marshes, wetlands, and beaches. CZMA provides grants to be used in maintaining coastal zone areas. It requires that Federal agencies comply with the enforceable polices of state coastal zone management programs when conducting or supporting activities that affect a coastal zone.

For the past 27 years, CZMA has provided coastal states and territories with incentives to properly plan and manage coastal resources through the development of coastal management plans. More than 99 percent of the nation s shoreline is currently covered under CZMA. The program is administered by the National Oceanic and Atmospheric Administration (NOAA).

Coastal Barrier Resources Act

In an effort to protect valuable coastal natural resources, to minimize loss of life and property, and to control the costs of Federal disaster relief efforts, Congress passed CoBRA in 1982. This Act prohibits most types of Federal assistance for development on designated barrier islands. Congress recognized that coastal barriers are unique ecosystems possessing great ecological value and subject to severe hazards which make these locations inappropriate for development and Federal investment. The Act designated various undeveloped barriers for inclusion in a Coastal Barrier Resources System (CBRS). These areas are ineligible for most federal financial assistance that might support additional development.

Regulatory Controls

- **Zoning codes** These codes are a form of land use regulations that set specific controls on where and how development can take place. In coastal areas, these often take the form of required set-back from high hazard and environmentally sensitive areas such as dunes, wetlands, or actively eroding shorelines.
- **Building codes** These codes set construction standards for withstanding the unusual forces exerted in a hazard event, such as high winds in a hurricane. Post-disaster assessments have proven that, in most cases, the use and enforcement of stricter building codes produce buildings that are more resistant to disasters. FEMA supports strong state and local building codes and can provide technical assistance to evaluate building codes and practices. FEMA also encourages the adoption and use of the new International Building Code (IBC), which incorporates multihazard disaster-resistant standards for construction.

Public Education and Outreach

- **Evacuation strategy** In recent years, hurricane warning systems have provided adequate time for people on barrier islands and the immediate coastline region to move inland. Devising and using an evacuation plan for communities in areas at risk is a necessary and vital exercise to safeguard lives. Due to rapid population growth, however, it is becoming more difficult to evacuate people from coastal areas because road improvements have not kept pace with development. Evacuation plans must be updated as needed and consider the capacity of the transportation infrastructure to move people away from the coast.
- **Warnings** Warning systems seek to reduce losses prior to the onset of a hazard event. An example is a system that automatically rings home phones to sound the alarm when floodwaters begin to rise.
- **Mapping** Maps that clearly delineate hazard zones are critical tools not only for local planners but also for residents, contractors, and engineers. For example, maps can identify high-risk areas that are prone to flooding or vulnerable to storm surge during a hurricane.
- **Disclosure** In real estate transfers, a standard notice can be placed in the written contract to warn all parties that a property is subject to natural hazards.
- **Education** Many people do not realize or understand the threat presented by hurricanes and other severe storms. The problem is further compounded by the fact that 80 to 90 percent of the population now living in hurricane-prone areas has never experienced a major hurricane. Many of these people have been through weaker storms. The result is a false impression of a hurricane s damage potential, which often leads to complacency and delayed actions that can result in the loss of lives in a more serious storm. Campaigns to inform citizens about areas that face the greatest risks from hazards, how to prepare for storms, and how to respond in a disaster can save lives and property.

Hurricane Case Study: River Communities in Recovery

Hurricane Floyd and Livability

The aftermath of Hurricane Floyd in September 1999 devastated the eastern third of North Carolina. As is typical for most hurricanes, it was not high winds or swelled seas that brought most of the damage, but flooding. Within just three of the state s 17 watersheds, flooding resulted in 52 deaths, the loss of millions of livestock, and the loss of 17,000 homes. Two-thirds of North Carolina counties were declared Federal disaster areas. An economic impact report prepared by FEMA and the EDA concluded that business and agricultural damage alone totaled $6 billion.

Eastern North Carolina posed unique opportunities for creating a more livable environment in the aftermath of enormous destruction. Watersheds clearly defined the disaster area. Because of this geographic characteristic, hazard mitigation and livability planning had to focus on the entire watershed, not individual communities. This approach fostered consensus and collaboration among people with diverse interests.

River Communities in Recovery

Three months after the disaster, FEMA committed its support to the River Communities in Recovery project and began bringing together other agency representatives from Washington and the region. In addition to FEMA, the EDA immediately stepped forward as an equal partner in the project.

The Governor s advisor on long-term planning issues, an executive with the North Carolina Rural Development Center (the institution responsible for the recovery process), and a representative of the Conservation Fund with close ties to the foundation community formed the team that would outline local needs. FEMA, EDA, and USDA officials met with the team to plan the River Communities in Recovery project.

Working with these state partners, FEMA established guiding principles for the project:

1. Federal agencies should provide long-term support, in the form of funds and technical assistance, in addition to immediate disaster relief. The focus is on matching Federal programs with community needs.
2. Federal agencies should be creative in finding ways to support local community needs. Community requests should not be rejected because they do not match Federal programs.
3. River Communities in Recovery should build local capacity for both short- and long-term watershed planning.
4. Federal support programs should focus on each river basin individually in accordance with jurisdictional boundaries to promote collaborative decision making.

FEMA, working with North Carolina Emergency Management, developed a job description for a Recovery Manager. This individual is to be actively engaged in the redevelopment efforts for the county and surrounding areas, and direct the recovery work of rebuilding the communities In addition, he or she serves as a mentor to other communities in terms of technical assistance.

Lessons Learned

At this time, the River Communities in Recovery project is where it should be: in the hands of local and state officials who will return to the Federal government with a prioritized list of projects that require financial or technical support.

There are many lessons to glean from the experience of launching River Communities in Recovery, including:

- The requirement for a broad community-based approach to include long-term recovery planning.
- The location of key Federal participants in the state or region, not in Washington, to facilitate the coordination of schedules and to improve long-term effectiveness.
- The need to build support for the initiative at all levels including Federal agencies, the state, and local leaders. This is especially important at the local level, where consensus must be built to establish and implement mitigation priorities and smart growth practices.
- The need to invite existing *Project Impact* communities to serve as mentors for other communities.

- Political subdivisions matter in disasters and sustainability if they get in the way of effective long-term sustainable redevelopment. Watersheds can break down these artificial boundaries, and Sustainability Planners should take a broad, inclusive approach to working with state and local officials both before and after disasters. (This same principle holds true for hazards other than flooding, e.g., consider forest ecosystem areas in wildfire mitigation planning and recovery.)

Coastal Storms Case Study: Project Impact Success Stories

Deerfield Beach, Florida, Wilmington, North Carolina, and Sanibel Island, Florida

The damage caused by coastal storms such as hurricanes has increased dramatically over time. Because this trend is expected to continue, it is important for those in harm s way to follow the lead of pioneering coastal communities that have already adopted risk reduction measures.

Two of these communities Deerfield Beach, Florida, and Wilmington, North Carolina are active participants in FEMA s *Project Impact: Building Disaster Resistant Communities*. *Project Impact* is a nationwide initiative that challenges communities to take proactive steps to reduce future disaster damages. It focuses on taking action in anticipation of disasters rather than just responding to disasters. The third community Sanibel Island, Florida illustrates the benefits of sustainable land use planning.

Deerfield Beach, Florida

Deerfield Beach is located on the southeast coast of Florida, in Broward County, 16 miles north of Fort Lauderdale. It is home to approximately 50,000 year-round residents. As one of Florida s low-lying oceanfront communities, the Deerfield Beach area is always susceptible to hurricanes, tropical storms, and flooding. Within the last 75 years, it has been hit by at least seven major hurricanes, including a 1928 hurricane that killed more than 2,000 people in the Lake Ockeechobee area.

In August 1997, FEMA and the State of Florida selected Deerfield Beach as a pilot community for the *Project Impact* campaign. As a pilot community, Deerfield Beach received technical and financial support to encourage efforts to create a disaster-resistant community. FEMA gave the city a grant of $1,000,000, and the local government committed $125,000 as a match.

Local and national businesses have pledged to join the city and FEMA in building a disaster-resistant community. The city organized a business alliance that invites businesses to meet monthly to discuss public/private partnerships in long-term mitigation strategies. Corporate partners including Home Depot, State Farm Insurance, Florida Power and Light, the Promous Hotel Corporation, and the Fort Lauderdale Sun Sentinel are participating in the city s *Project Impact* initiative. In its Deerfield Beach store, for example, Home Depot created a display on disaster resistance and offers short courses for local homeowners on steps to protect against future storm damage.

Specific accomplishments and projects include the following:

- State Farm Insurance funded and designed the Good Neighbor House which was constructed to withstand a Category 5 hurricane with 156 mile-per-hour (MPH) winds. The model house demonstrates how common-sense building materials and techniques can protect a structure from hurricanes. Before Hurricane Floyd hit North Carolina in 1999, between 40 and 50 people toured the Good Neighbor House in Deerfield Beach every week. After Floyd, more than 100 people arrived on a single Saturday to view the 100-plus safety features. State Farm estimates that many hurricane-proofing measures, such as impact-resistant windows and properly nailed shingles, can be added to a house for an extra 5 percent of the total cost of the structure. The model house builds awareness in the community of materials and techniques that can be used to build stronger homes and demonstrates that hurricane-resistant construction is not as difficult or expensive as many believe.

- Marina One, a developer, broke ground in 1999 on the Marina One Yacht Club, which can house more than 200 boats in a steel and concrete structure designed to withstand winds of up to 125 mph. The new facility is the first of its kind in the marine industry, offering 2,600,000 cubic feet of hurricane-resistant marine storage.
- The Deerfield Beach Chamber of Commerce building was retrofitted with hurricane-resistant windows provided by Solutia, Inc., which became a *Project Impact* corporate partner in 1999. As part of Solutia s partnership, the company made a commitment of $200,000 in materials and labor toward the retrofitting of commercial and residential structures in hurricane-prone communities nationwide. Solutia is providing its hurricane-resistant KeepSafe Maximum glass along with technical support. The special glass is an impact-resistant laminated glass that meets the most stringent building code requirements, including those mandated by the State of Florida. It is formed by bonding two pieces of glass to a hardy polyvinyl butyrol (PVB) plastic interlayer, which is produced by Solutia. This product will not shatter and fall out upon impact.
- Deerfield Beach is a partner with Broward County in the development of a Broward County Community Emergency Response Team (CERT). To date, 75 residents have completed the CERT Training Program.
- Deerfield Beach is taking an active role in public outreach and education. *Project Impact* funds ($150,000) were used to put hurricane straps on the auditorium and cafeteria of the local high school, which also serves as a shelter during disasters. Wind shutters are to be installed on all the windows in the high school as well as those in the Deerfield Beach City Hall.
- The City of Deerfield Beach, Broward County, and the State of Florida are each hosting a Preparedness Week in late spring just before the hurricane season begins. The three-week program includes technical conferences as well as public events designed to raise awareness of mitigation strategies. The Corporation for National Service is helping to organize a Spring Break a week for volunteer participation in *Project Impact* activities. The community designated a full-time staff member as a hazard mitigation coordinator for *Project Impact*.
- Construction in Deerfield Beach is already regulated by the state s building codes which are among the most stringent in the country. Deerfield Beach is also in the process of developing a citywide storm drain system to provide protection from the damage associated with hurricane flooding.

Deerfield Beach has outlined several major goals still to be accomplished as part of its *Project Impact* program. These include:

- Retrofit of all public buildings and critical facilities against hurricane and flood hazards.
- Development and implementation of a home retrofit program.
- Identification of incentives for residents to pursue mitigation measures.
- Improvement of the efficiency of building and land development regulatory systems.
- Development of a comprehensive all-hazard education and outreach program.
- Creation of a marketing strategy to showcase disaster resistance.

This area boasts a history of strong building codes and engineering and enjoys the support of community residents and businesses in promoting sustainability. City, county, and state officials continue to create and implement effective mitigation strategies that will benefit the entire Deerfield Beach community.

Wilmington, North Carolina

Wilmington is located approximately 30 miles from the Atlantic Ocean, at the junction of the northeast and northwest branches of the Cape Fear River. It is the largest city in New Hanover County and home to approximately 148,000 people. Many of its residents are retired.

Wilmington is frequently hit by severe coastal storms. Hurricane Bertha, which struck in 1996, caused an estimated $17 million in damage to homes, businesses, and utilities in New Hanover County. Eight weeks later, Hurricane Fran, which also ravaged counties far inland with its destructive winds and rain, caused an estimated $240 million in damage.

FEMA also selected Wilmington and New Hanover County as a pilot community for the *Project Impact* campaign. Partners in the *Project Impact* program include FEMA, the North Carolina Division of Emergency Management, New Hanover County Emergency Management, the City of Wilmington, and private-sector entities such as General Electric, Lowe s Hardware, Barnes and Noble, and WGNI-FM Radio.

The devastation from Hurricane Hugo in 1989 created a push in North Carolina for more stringent building codes. In 1996, the state promulgated and began enforcement of a new set of regulations that require stronger and safer construction. In 1997, Wilmington launched its *Project Impact* campaign to reduce the effects of natural disasters. The campaign included an ordinance that required propane tanks to be anchored to prevent them from floating free in floodwaters, beach stabilization, and dune renourishment to protect against storm surge.

Among Wilmington s accomplishments are the following:

- Hurricane Bonnie hit Wilmington in 1998. Officials believe that efforts to make the community more disaster resistant demonstrated that *Project Impact* produces positive results. Although hurricane winds pounded beach communities for as long as 13 hours, homes elevated after Hurricane Fran in 1996 and rebuilt using hurricane straps survived Bonnie without major damage. The benefits of elevation were apparent at Wrightsville Beach, where 80 new or elevated homes escaped damage. Many older structures, in contrast, lay partially submerged under 2 feet of water. The public safety communications tower that went down during Hurricane Fran was retrofitted to be flood and wind resistant. The new tower easily switched to generator operations, and all systems stayed on line during Hurricane Bonnie.
- Nearby Wrightsville Beach initiated an LP gas tank ordinance, requiring that all tanks be dropped and secured to eliminate potential floating problems. This preventive action eliminated possible explosions and fire damage when Hurricane Bonnie hit.
- Lowe s, a *Project Impact* partner, distributed hurricane season preparedness brochures in its 90 stores located in coastal states. It also developed in-store displays to educate customers about home damage prevention measures.
- New Hanover County Emergency Management (NHCEM) supports training exercises and drills, participates in county disaster awareness programs, and staffs the emergency operations center. At its own expense, NHCEM installed an 800-MHz two-way radio communications network to mitigate against the breakdown of communication across jurisdictional and agency boundaries.
- Wilmington also renovated its Sweeney water plant. The plant is now located out of the 100-year floodplain and is designed to withstand 120 mph winds. It also has two 1,250-KW diesel generators, which supply all of the power needed in the event of an emergency.

The sustainability initiatives and community partnerships described above demonstrate Wilmington s determination to bolster itself against future disasters. The promotion of safety measures, such as elevating homes, contributed to property owners increased interest in storm protection. Hurricane Fran was a bitter lesson for many residents of North Carolina. Wilmington took action by implementing damage reduction measures. It has realized the benefits of mitigation in the wake of Hurricane Bonnie. Other communities in the coastal region have expressed interest in the education programs of *Project Impact*.

Sanibel Island, Florida

The Town of Sanibel Island is a barrier island located in Lee County on the west coast of Florida. A causeway connects the island to the City of Fort Myers on the mainland. Sanibel Island, about 12 miles long and 3 miles wide, has a permanent population of 5,700 and a seasonal population of more than 20,000.

Sanibel Island is a successful model for environmental concern and sustainability planning. Wildlife refuges and other natural areas, including the Darling National Wildlife Refuge, protect much of its landmass. The remainder of the island is subject to carefully controlled development. Stringent zoning codes and a comprehensive land use plan ensure that no high-rises, traffic lights, or multilane roads mar the island s natural beauty.

Concerned about uncontrolled development, island residents incorporated the island as a township in 1974. The town convened a panel of scientific and technical experts to explore the relationships of the island s resources to the larger ecosystem and to recommend specific controls. In 1976, the town devised and adopted its first plan and development regulations.

A principal goal of the town was to conserve its natural resources. One of the major habitats targeted for protection was a large area of freshwater wetlands threatened by physical disruption and drainage. Protecting the wetlands would provide habitat for wildlife, aesthetic and recreational pleasure for people, and flood control for the community. The town used municipal land use ordinances and prevailed on state and Federal authorities to use the most restrictive environmental standards possible to prevent development of the wetlands. The community eventually purchased much of the wetlands area outright. Today, a large part of Sanibel remains free of development and in a pristine state.

On the remainder of the island s land, the size and character of development are strictly controlled. Building height is limited to three stories, or 45 feet. All floors must be above base flood elevation (BFE). No more than three units can be built on 1 acre. To minimize the threat posed by storm surge and coastal flooding, the island imposed a minimum setback line for all development along the waterfront. The town has also encouraged the relocation of buildings threatened by the encroaching ocean. In several cases, residents have engaged in roll-back activities by having their houses lifted and moved farther from the water.

In 1980, Sanibel instituted a cap on growth to maintain a more manageable set of infrastructure and service obligations, to prevent excessive demands on the natural environment, and to preserve the island s quality of life. Although caps on growth are typically difficult to implement and even more difficult to defend in court, Sanibel Island devised a unique and defensible solution. It hired land use consultants to calculate the number of people that could be safely evacuated from the island. Reasoning that it would be irresponsible to allow more inhabitants than could be moved safely in the event of a storm, this number became the basis for the growth cap. Sanibel recognized the threat posed by coastal storms, determined a safe carrying capacity, enforced a growth cap, and reduced its vulnerability to future disasters.

As a result of these measures, Sanibel Island has avoided the mass of high-rise condominiums and commercial establishments that typified development in much of coastal Florida during the 1980s and 1990s. Instead, it is following a more sustainable path. It has set aside large natural areas for protection and guided development in a way that maintains the historic and natural character of the island environment and lessens the threat posed by coastal storms.

4.5 Tornadoes

A tornado is a rapidly rotating funnel of air extending from a thundercloud toward the ground. Most of the time, these funnels do not touch down, but when they do they can last for a few seconds to several minutes, and cause severe damages. Tornadoes usually are accompanied by heavy rain, hail, and lightning. The most violent tornadoes are capable of tremendous destruction, with wind speeds of 250 mph or more. Because the geographical scope of damage is usually narrow (i.e., less than 1 mile in width and several miles in sustained path length), a tornado is typically not a Federally declared disaster. Tornadoes can occur in any state, but are more frequent in the Midwest, Southeast, and Southwest. Tornado season ordinarily runs from March through August; however, tornadoes can strike at any time of the year.

The impact of a tornado varies with its strength, the duration of touchdown, and the physical integrity of the buildings or other structures in its path. Tornadoes can uproot trees and damage structures even at wind speeds of 100 mph. Much of the damage results from high-velocity flying debris. Inadequately built structures, manufactured homes, and mobile homes are the most vulnerable to substantial damage from tornadoes. The intensity of tornadoes is measured by the Fujita Scale, from less severe (F1) to the most severe (F5).

Mitigation and Sustainability Approaches

Extent of Damage

In many cases, the tornado path is narrow enough that restoration of the damaged areas to predisaster conditions is the most appropriate planning strategy to preserve coherent land use patterns. In other situations, tornadoes have been known to destroy considerable portions of communities, resulting in significant opportunities for sustainable redevelopment (see Arkadelphia Case Study).

Type and Age of Affected Facilities and Structures

- In cases where predisaster conditions will be restored, there is significant room for improvement by recommending the use of more effective wind-resistant and energy-efficient building materials.
- In recovery situations where extensive damage occurs in older residential neighborhoods, the Sustainability Planner should consult with local officials to determine community interest in evaluating alternative reconstruction strategies. Current housing needs should be evaluated to guide reconstruction efforts. The zoning code should be reviewed to determine if a greater diversity of housing types is possible.

Land Management and Construction

There are a variety of techniques that can help reduce losses from tornadoes:

- Using inexpensive metal connectors or strapping to strengthen the connection between the roof and walls, and walls to foundation, to reduce the uplift effect of strong winds.
- Reinforcing or replacing garage and double entry doors.
- Removing trees and yard materials that, in a storm, could become windborne missiles.

Regulatory Controls

The Sustainability Planner should check current building codes to see if they require commonly accepted wind-resistant building techniques, such as:

- Anchoring of walls to foundations and roofs to walls.
- Reinforced walls, floors, and ceilings.
- Tornado safe rooms in new construction and the retrofitting of existing structures to provide the most complete protection from extreme wind events.
- Community tornado shelters for mobile home communities.

The exact location where a tornado touches down is one of nature s most random events, and the probability of future occurrences in the same area is difficult to estimate. Recommending regulatory controls as a sustainability initiative should be considered only in those portions of the country with the highest potential risk. However, as Xenia, Ohio illustrates, tornadoes can strike the same place more than once. Xenia, struck by an F4 tornado on September 20, 2000, has suffered four major tornadoes in the last 80 years, including an F5 storm in 1974.

Public Education and Outreach

- Safe rooms and other wind-resistant construction techniques should be promoted through community meetings, workshops, and exhibits at local businesses. Consult FEMA s Mitigation Outreach Branch for assistance.
- Special efforts should be made to inform mobile home residents about the effects of tornadoes and the location of safe shelters.

Tornado Case Study: Arkadelphia Recovery Plan, City of Arkadelphia, Arkansas

At approximately 2:45 pm on March 1, 1997, a tornado touched down just southwest of the City of Arkadelphia, Arkansas. It caused extensive damage to residential areas and the downtown business district. The National Weather Service classified the tornado as an F3 to F4 storm event on the Fujita Scale. The funnel was just one of a series of tornadoes that resulted in significant damages along a 260-mile corridor through the central portion of the state. Preliminary estimates indicated that at least 256 single-family homes, mobile homes, or multifamily units sustained major damage and 117 were destroyed; 46 businesses and 16 public buildings were damaged or destroyed.

The City requested FEMA s assistance in evaluating reconstruction strategies and preparing a Disaster Recovery Plan. Through HMTAP, FEMA provided direct technical assistance to the City. The project planning team included planners with national experience in disaster response and recovery, together with local experts in planning, urban design, and economic development.

Within days of the tornado, Arkadelphia established a recovery task force, and committees for housing, transportation, unmet needs, and media coordination were quickly formed. A smaller subcommittee of the recovery task force, limited to 8 to 10 members, was established to work closely with the project planning team.

Within 2 weeks of the disaster, the project team conducted what is known in the architectural and urban design profession as a charrette an intensive urban design and land use planning exercise. During the day, project team members developed base maps, obtained background information, and developed alternatives for the recovery effort. Committee meetings were held in the late afternoon to develop goals and objectives.

A draft recovery plan was prepared within 1 month, and it was presented to the broader community at several public meetings. The final recovery plan was completed within 2 months of the tornado and was formally adopted by the City Council. The reconstruction master plan included an assessment of disaster damages, presented reconstruction design principles for housing and for the downtown business district, recommended changes to the zoning ordinance and building code, and included economic analysis and summary recommendations for immediate, short-, and long-term recovery.

The recovery plan included the following sustainable redevelopment elements:

- Adoption of the latest version of the Southern Standard Building Code and bringing all other applicable construction and fire safety codes up to date.
- New urbanism principles, emphasizing mixed-use development downtown to include housing and to foster new economic growth and revitalize residential neighborhoods.
- Recommendation of changes in zoning ordinances to allow a greater diversity of housing types and to maintain the historic character of the downtown business district. This was accomplished, in part, by a disaster overlay district and by urban design guidelines.
- Incorporation of energy efficient materials promoted by DOE into the reconstruction of substantially damaged homes.
- Implementation of an innovative equity buy-down program promoted by HUD to finance single-family home construction.

Several lessons learned during this long-term recovery planning effort are worthy of note:

- There should be a clear understanding of what a FEMA-funded recovery planning effort can accomplish considering time and resource limitations. In Arkadelphia, some key local officials expected a detailed block-by-block master plan. FEMA provided a broad framework for recovery planning. Detailed program and engineering design were to follow.
- The recovery planning process provided an effective mechanism for bringing in other Federal agencies to participate in long-term recovery. The HUD representative for Arkansas participated in the charrette and worked closely with the community to target HUD resources to community needs. Following the initial recovery planning effort, HUD used Community Development Block Grant (CDBG) funds to support development of a comprehensive 1-year master plan.
- National experts on disaster recovery must work hand-in-hand with local planning and urban design specialists.
- A construction moratorium can be effective in providing the necessary time to develop a reconstruction strategy. The recovery planning team worked closely with the local government to enact a 30-day moratorium, which was carefully crafted to permit necessary repairs and applied only to substantially damaged structures.

4.6 Wildfires

Wildfires can be devastating in terms of geographic scope. Contributing conditions such as climate, fuel, and rural development in remote mountainous or forested areas make some states more vulnerable than others at different times. The key issue for the Sustainability Planner is the urban-wildfire interface a boundary zone between developed areas and surrounding forests or chaparral. Land management and regulatory programs to minimize future disaster damages should focus on the urban-wildfire interface. As the Wildfire Case Study illustrates, public education and outreach programs are an effective mitigation measure for residents in high fire hazard areas.

Damages include disruptions to electric, water, sewer, and telecommunications utilities; destruction or damage to valuable environmental, economic, and historical resources; roadway blockage; disruption of community services; devastation of agricultural/fishery economies; and human loss and suffering. Additionally, water absorption and retention are significantly reduced when the majority of plant cover is removed by fire, thus creating the potential for future floods or landslides.

Mitigation and Sustainability Approaches

Land Management and Construction

- Create a fuel management program to reduce available fuel, establish fire-resistant vegetation, and construct fuel breaks and firebreaks in the urban-wildfire interface.
- Use nonflammable building materials (especially roofing) tile, stucco, metal siding, brick, concrete block, and rock and plant fire-resistant shrubs and trees.
- Create 30- to 100-foot safety zones around homes by raking leaves, dead limbs, and twigs.

Regulatory Controls

In selected geographic areas of the country and in special ecosystems such as pine barrens or chaparral along the southern California coast, communities may consider zoning regulations to reduce residential densities in high hazard areas, encourage cluster development, and delineate urban-wildfire interface zones. Urban growth boundaries tied to the concept of urban-wildfire interface designations is a planning approach that may merit consideration by the Sustainability Planner.

Public Education and Outreach

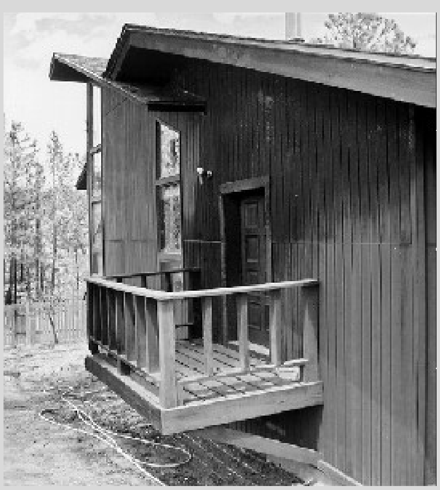
Public outreach programs are probably the most effective sustainability initiative in most fire disaster declarations. The Sustainability Planner should consider developing educational materials to encourage residents to:

- Store gasoline, oily rags, and other flammable material in approved safety cans away from the base of buildings; dispose of newspapers and rubbish at approved sites; and prune tree branches and remove vines from walls.
- Stack firewood at least 100 feet away and uphill from homes; place stove, fireplace, and grill ashes in a metal bucket, soak in water for 2 days, and then bury in mineral soil.
- Regularly clean roof and gutters, inspect chimneys, and equip chimneys and stovepipes with spark arresters.
- Identify and maintain an adequate outside water source such as a small pond or swimming pool; have a garden hose long enough to reach any area of the home and other structures on the property.

Wildfire Case Study: Measures of Mitigation Success New Mexico

The Cerro Grande fire began in the late evening on Thursday, May 4, 2000, when a prescribed burn to reduce fuel loads ignited. Sporadic wind changes caused spotting over the fireline. By early afternoon on the following day, the prescribed burn was declared a wildfire. The fire spread rapidly over the next few days through the Ponderosa pine, mixed-conifer, and aspen forest on public, private, and Pueblo lands. By May 10, the wildfire carried by very high winds reached the community of Los Alamos, New Mexico. Approximately 18,000 people were evacuated from the towns of Los Alamos and White Rock. The fire continued to spread to the communities of San Ildefonso and Santa Clara Pueblo, encompassing a total area of approximately 42,900 acres. A total of 235 residences and an assortment of other structures were damaged or destroyed.

The Miracle House



The damages sustained by the McDonald residence in Los Alamos, NM were limited to the west end of the home.

Although wind-swept flames quickly engulfed many residences and structures, a 3,300-square-foot wood frame house in Los Alamos, owned by Thomas and Myrna McDonald, escaped with only a moderately singed west side. Their home now has a name the Miracle House which it well deserves.

There are 25 homes on the north side of Ridgeway Drive. The fire approached

Myrna McDonald holds open the severely singed solid core door that prevented flames from entering the interior.

Part of the ongoing maintenance at the McDonald residence included the regular removal of pine needles and other ground debris from around the house.

from the west and quickly spread eastward, destroying all but three homes before it was contained by firefighters. One of the three that escaped the blaze was the McDonald residence. The street itself acted as a firebreak that saved homes on the south side from the flames.

The McDonalds began practicing a mitigation program of proactive grounds maintenance when the house was built 25 years ago. They work steadily to keep their property free of ground fuel, underbrush, and low tree limbs. I rake up and cart off the pine needles that fall from the trees on a regular basis, said Myrna. The last time I did so, which was a week before the fire on the front side and 2 days before in the back and side yards, proved to be the most important thing we did that saved our home. They also pay close attention to the trees themselves, and regularly prune off branches that could make contact with the house and provide a fire with a bridge to the structure.

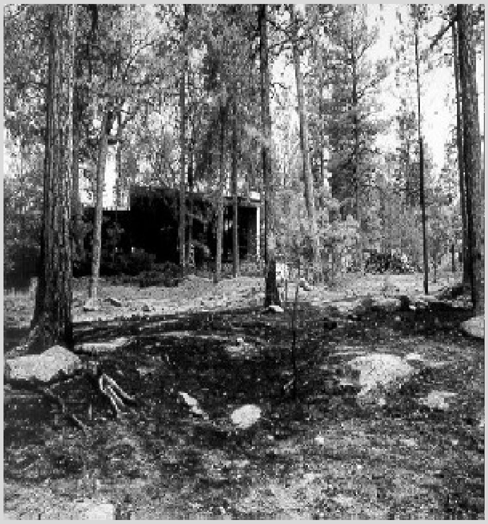
When designing their home, the McDonalds included several items that helped save it from major damage during the fire. They installed double-paned windows and solid core doors. The flames that destroyed the home to our west were extremely fierce. They melted its chimney lining, which fire fighters say need to exceed 2,500 degrees. Flames shattered the outer layer of glass in our windows, but did not break the inner layer. Our home did not suffer any major smoke damage because of this. Also, the small side porch was burned, our west wall singed, and our entry door was severely scorched but the flames did not get through it. Had this door not been solid wood, I feel that our house would also be listed among those that were lost to the fire.

The McDonald home had only minor exterior damage. Homes on both sides were completely destroyed by flames.

Thomas and Myrna McDonald credit the Los Alamos Fire Department for their home s survival. We evacuated the afternoon of the (May) 10th, and the fire struck our street around 3 a.m. on the 11th. When the fire department arrived and saw our home still standing while those on both sides were already going up in flames, they took immediate action to save it. They sprayed the sides and roof with (fire retarding) foam, which prevented major damage to and possibly even the loss of our home.

Positive action by the McDonalds paid off. Because of choosing appropriate building materials, and instituting a conscientious program of regular upkeep and maintenance, they did not become victims of the Cerro Grande fire. The damage to their home was limited to a burned porch, a singed wall, and a scorched door that can be repaired or replaced. The home itself a place filled with memories still stands.

The McDonalds credit the use of double-paned windows as one of the construction barriers that prevented the fire from entering their home. The outer layer absorbed the fire s force and shattered.



A mitigation plan and measures undertaken by Harold and Joyce Cady helped save their home from destruction by the Cerro Grande.

Residential Mitigation Planning

Transforming a 3-acre wooded lot from a rambling array of overgrown undergrowth and saplings into a fire-mitigated wooded area helped save Howard and Joyce Cady s home during the devastating Cerro Grande fire. This wildfire destroyed more than 200 homes in Los Alamos on May 11 and 12, 2000. A long-term mitigation plan, begun in the spring of 1998 when they purchased the home on 47th Street, involved a lot of work and very little money.

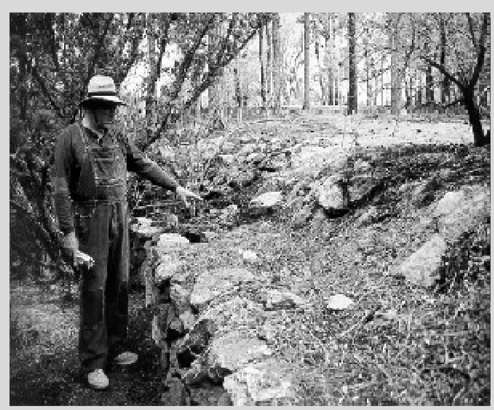
When we bought this 55-year-old wood frame house 2 years ago, we knew it would be susceptible to destruction by fire, said Howard, so I contacted the United States Forest Service (USFS) district office in Santa Fe for a professional assessment. A ranger came out, inspected our land and made several valuable recommendations. The first was to remove the tangled vines and brush that grew thickly throughout the acreage. Working five to six hours daily, he made progress cleaning up the area. Soon, Harold had a fire mitigation zone that was free of ground fuel. Total cost: a chain saw, hand tools, and dedication.

An 8-foot-wide firebreak prevented the flames from getting to the Cady home. Note the fire-ravaged trees to the left of the break and the healthy, untouched vegetation to the right.

Once the undergrowth was removed, Harold set about on the next task: cutting saplings, thinning out medium-sized trees to remove the ladder system leading to the crowns of mature trees, and pruning all branches to a point about 10 feet off the ground. The ranger marked the trees that were most likely to fuel a fire in the tops of the large trees. An added benefit of all this thinning and pruning was an ever-expanding woodpile, stacked and ready to provide us with fuel for the coming winters. A regular work schedule brought about the intended results.

A third area of consideration was access to the rear of the property. With the help of the USFS, Harold mapped out fire roads that encircled all sides of his home. First, we removed all plant growth and then kept these areas cleared year-round, Harold said. This created a series of natural fire breaks, about 8 feet wide, that helped to separate our home from potential fire hazards.

Their efforts proved valuable when a section of the Cerro Grande fire swept down a hillside into Los Alamos and destroyed homes beginning at 47th Street and continuing down Ridgeway Drive. When the Los Alamos Fire Department and the Forest Service arrived, a number of homes in the subdivision were already



Harold Cady points out one of the many areas on his property where clearing out the undergrowth and continual maintenance helped protect his home from the Cerra Grande fire.

engulfed in flames. Although the fire burned many trees that surrounded the Cady home, the house itself was spared.

The firefighters knew where our roads were, so they were able to enter the woods surrounding our house and control the burn. They foamed the house with fire retardant chemicals and kept the flames from jumping our firebreak. When we thanked the crews for saving our home, they told us that what we had done the cleaning, the thinning, the pruning, the fire break had made our house defensible.

A hunting camp in the mountains above Ruidoso survived the Cree fire, though several nearby retreats and year-round homes were destroyed. Mitigation measures taken by the owner, the Ruidoso Fire Department Chief, proved successful. He had cut a wide firebreak between the forest and his cabin, and removed the underbrush and lower branches on the trees. The fire came within 15 feet of the sructure, but was effectively halted in its path by the lack of ground and ladder fuel.

A look at the Cady property reveals several mitigation measures. Although the woods surrounding the home suffered burn damage, the Cady home was made defensible by creating a firebreak, removing undergrowth and vines, cutting down small and moderate-sized trees, and pruning limbs to about 10 feet off the ground. The woodpile was located about 30 feet from the house.

4.7 Landslides

Landslides occur when masses of rock, earth, or debris move down a slope. They are influenced by human activities or natural factors, such as geology, precipitation, and topography. Landslides occur all over the United States, but are most common in California, Colorado, and the Appalachian Mountains. They may account for a few cubic yards or extend hundreds of feet and include entire hillsides. A debris flow is a type of landslide where rapidly moving slurry masses consisting of soil, rock, water, and vegetation take on the consistency of mud and reach high velocities as they flow downhill. Debris flows are usually induced by rainfall and tend to recur in the same drainage areas. Landslides can be triggered by heavy rains, floods, earthquakes, and volcanic activity.

Mitigation and Sustainability Approaches

Land Management and Construction

Land use planners should consider the history of past landslides; bedrock type; slope; the presence of sandy soils; and hydrologic factors, such as high water tables and frequent freezing and thawing cycles. Some specific mitigation measures are:

- Install catchment basins to control runoff in landslide hazard areas.
- Plant ground cover and install riprap to hold soil in place on hillsides or slopes.
- Build retaining walls along essential evacuation routes.

Regulatory Controls

In areas highly susceptible to landslides, the following regulatory controls should be considered:

- Adopt a grading ordinance that requires geotechnical investigations in designated high hazard areas to analyze slope stability, provide surface/subsurface drainage specifications, and develop detailed design for fill placement and excavation.
- Use zoning to control maximum density, minimum lot size, road width, and setbacks in areas of high or severe landslide risk.
- Adopt soil conservation, slope stabilization, open space dedication, or steep slope ordinances.

Public Education and Outreach

- Provide information to homeowners on the benefits of installing flexible pipefitting to avoid gas or water leaks, and improving drainage around structures and property.
- Post community warning signs of potential landslide hazards.
- Map areas susceptible to landslides and post these maps on a community website and in the local planning or building permit office.
- Advocate early disclosure of hazard in real estate transfers.

Landslide Case Study: Multihazard Risk Assessment for Rural Municipalities

Puerto Rico

Puerto Rico has been struck by five natural disasters since 1989. The extent of damages to homes, businesses, and public infrastructure, and the corresponding disruption to the local economy, are strong arguments for a new approach to land development. FEMA Region II used HMTAP resources to assist seven rural municipalities devastated by Hurricane Georges in 1998.

This local planning effort involved developing a multihazard risk assessment for each community and holding a series of public meetings to identify and prioritize recommendations to create disaster-resistant communities. Existing GIS data on topography, floodplains, geology, and soils provided the foundation for the natural hazards analysis. The risk assessment involved mapping physical and land use data, and then evaluating opportunities and constraints for both reconstruction and future development. In addition to landslide hazards, flood, high wind, and earthquake hazards were analyzed. The risk assessment was then linked to a land suitability analysis to identify future growth areas, areas where new development should be discouraged, and areas where specific engineering design or Best Management Practices (BMPs) should be implemented. Several communities have already required that the findings of the multihazard risk assessment be incorporated into their comprehensive plans.

Local government representatives, planning commissions, and interested residents participated in three rounds of community meetings. The first meeting focused on public concerns; the second, on the multihazard risk assessment methodology and prioritization of planning recommendations; and the third, on those measures the community can readily adopt to institutionalize hazard mitigation at the local level.

Landslides can vary in size from a few cubic yards of soil to entire hillsides hundreds of feet long. Puerto Rico s steep topography combined with shallow, fine-grained soils over bedrock increases its susceptibility to landslides. Many of the landslides during Hurricane Georges occurred along road cuts or fills. An island-wide landslide susceptibility map prepared by the U.S. Geological Survey (USGS) delineates much of the central volcanic portion of the island as being prone to landslides.

As stated in FEMA s Building Performance Assessment Report (BPAT), prepared in the aftermath of Hurricane Georges, Landslides will become a greater problem in the future as more developments and houses are constructed in regions prone to such risks. To address this concern, project team geologists and geotechnical engineers conducted fieldwork and reviewed past technical studies to develop a landslide susceptibility methodology for use in the multihazard risk assessment.

This susceptibility analysis focuses on the risk of landslides caused by cutting and filling on natural slopes. Slope and bedrock geology are the two major determinants of susceptibility to landslides. A slope map derived from Digital Elevation Model (DEM) data combined broad slope classes with data on geologic formations to identify areas prone to erosion.

The following landslide mitigation recommendations were included in the final reports for the seven rural municipalities:

- Avoid intensive development in areas of historical landslide deposits.
- Discourage development in areas with natural slopes steeper than 50 percent. Consider limiting the number of times that property can be subdivided or limiting the density of development. Do not allow the construction of private roads in areas with slopes greater than 50 percent.
- Encourage future development where natural slopes are flatter than 35 percent; stable cut-and-fill slopes can be economically constructed in such areas, and the risk of slope failure is low.
- To limit contact with debris flows, avoid development within and directly below steep-sided drainages that extend up hillsides.
- Design all major cut-and-fill slopes in accordance with standard engineering practice. Consider adopting a hillside grading ordinance that requires a geological risk assessment report, a geotechnical engineering report, compaction specifications, suitable fill material, surface and subsurface drainage, maximum default cut-and-fill slope inclinations, and procedures for inspection and enforcement.